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ABSTRACT

At the end of 1978, there were approximately 230 nuclear-fueled electric generating plants around the world; 72 of these were in the United States. Each plant requires an operations-and-maintenance workforce of 92 people, and attrition occurs at a rate of 8% per year. Requirements for a nuclear taskforce and job training, in view of current development rates, are running high. Seven major technical occupations appear to be specific to nuclear-fueled electrical generating plants: power plant (reactor) operator, radiation protection technician, quality-assurance/quality-control technician, nuclear instrumentation and control technician, chemical technician, mechanics, and electricians. Training programs for these occupations exist through 21 postsecondary schools and through employer programs. Before committing themselves to a nuclear program, school administrators and curriculum planners should consider the following factors: (1) employer needs within the school service area; (2) relevance to industry pre-employment levels; (3) convenient location to reactors for specialized training; (4) absorption of program costs; and (5) public education to counteract adverse publicity. A list of instructional materials is included and appendices contain a list of schools with nuclear programs, job descriptions, a sample local needs survey, and examples of industrial and governmental training programs. (MB)

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ED168651

NUCLEAR

TASKFORCE SUMMATION

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January 15-17, 1979

The National Education,
Business and Labor Conference
on Energy-Related Vocational
and Technician Training,
Employment and Public Energy Awareness

Sponsored By
The Department of Energy
Office of Education, Business and Labor Affairs

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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JC 790 234

THE NUCLEAR TASKFORCE COMMITTEE

The Office of Education, Business and Labor Affairs is especially grateful to the host of individuals who contributed great quantities of time and effort to the development of this conference, especially the Nuclear Taskforce Committee:

Mr. Ronald L. Kathren (Staff Scientist)
Batelle - Northwest

Dr. Maurice W. Roney (President)
Texas State Technical Institute

Mr. William Berndt (Project Officer)
Dept. of HEW, U.S. Office of Education

Mr. Paul Shoop (International Representative)
International Brotherhood of Electrical Workers

Mr. Paul F. Collins (Chief, Div. of Reactor Licensing)
Nuclear Regulatory Commission

Mr. Richard J. Marzec (Manager of Technological Training)
Duke Power Company

Mr. John P. Martelli (Manager of Training)
Rockwell-Hanford Operation

Mr. Harold H. Young (Chief, Institutional Programs Branch
Dept. of Energy, Education Programs Division

Thanks to these people and the conference speakers they have elicited, a highly useful nuclear energy dimension has been developed for this conference.

Daniel M. Hull, Chairman
General Manager
Technical Education Research
Center - Southwest

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PART ONE

This brief overview of America's Nuclear Workforce relates to career opportunities - the kinds of jobs available, and how many - and how this workforce is trained. It deals specifically with the past, present and future roles of postsecondary, two-year technical-vocational schools and community colleges in the preparation of nuclear-fueled electrical power plant operators, technicians and maintenance workers.

Even at current development rates, requirements for such a workforce are running high.

INTRODUCTION

Nuclear fission - atom splitting - generates heat; this heat provides an energy source for electrical power production. The worldwide impact of nuclear energy for generation of electricity is steadily increasing. At the end of 1978, seventy two on-line nuclear-fueled generating plants were providing nearly fifteen percent of America's electrical energy. By 1990, about one-fourth of our generating capability will be nuclear fueled. Outside the United States, nations on nearly every continent are looking to nuclear fuel for electrical power generation. Nuclear technology has come of age.

This growth has not been without its problems, however. In spite of an admirable safety record, considerable opposition has developed to the growth of nuclear power. This antipathy, in addition to conservation efforts and changing regulatory requirements, has had a damping affect on new plant orders. Nevertheless, for baseload* generation of electricity,

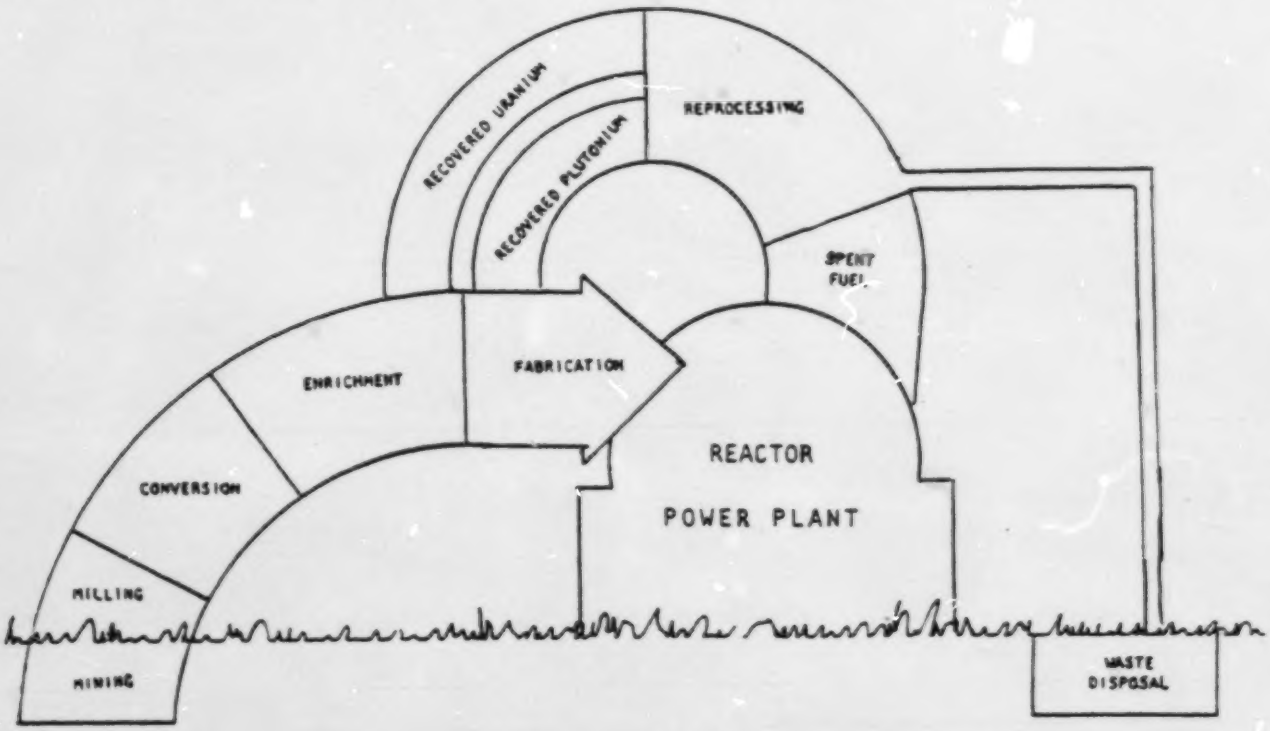
*Normal production.

nuclear fuel will make a growing contribution to new demands for the remainder of this century.

A substantial workforce is required to operate current and projected nuclear plants safely and efficiently, and to provide and handle the fuel for them. A critical sector of this workforce is composed of those in nondegreed technical occupations.

Extensive training efforts are underway by employers to mobilize the required workforce in a timely manner. Two-year, postsecondary institutions need to support this effort in a significant way with high-quality, job-relevant institutional programs. Surprisingly few such programs are being offered currently. (See Appendix A).

This report addresses the preparation of operators and technical specialists exclusively related to the nuclear power industry. It is recognized that technical occupations also exist in other phases of the nuclear fuel cycle, but these are beyond the scope of this conference.



CAREER OPPORTUNITIES

Recent workforce needs assessments, made by the Technical Education Research Center (supported by a strong national steering committee comprised of employers of nuclear operators and technicians), identified current (1977) needs in industry for half a million people with nuclear skills and knowledge, including several technical occupations and crafts in or directly related to electrical (power plant) energy generation and reactor operation.

Seven major technical occupations appear to be specific to nuclear-fueled electrical generating plants.

Power Plant (Reactor) Operator

Nuclear plant operators, for the purpose of this report, include all individuals employed by a utility who are responsible for the safe and efficient, day-to-day generation of electricity or process steam. These employees include licensed operators and power operators, as well as auxiliary equipment and utility operators. (See job description for entry level operator in Appendix B.)

Although each utility has its own job titles, the functional levels of responsibilities on a typical shift would include a senior operator as the individual who directs the activities of licensed and nonlicensed operators. The licensed operator, who is responsible for manipulation of controls, mechanisms and equipment operable from the principle control room, may be assisted in these tasks by nonlicensed individuals.

The auxiliary equipment and utility operators normally perform tasks outside the control room that are necessary for safe and efficient operation of the facility. These tasks include positioning of valves, operation of auxiliary equipment, monitoring of local instrumentation associated with operating equipment, operation of radiation waste systems, and performance of housekeeping duties.

Normally, individuals progress through the different levels of responsibilities until they have become senior operators. As they progress, they must become more highly trained. Unlike fossil plant operators, nuclear plant operators rarely receive all their training on the job. Instead, the Nuclear Regulatory Commission (NRC) requires that, at the time of initial fuel loading of a nuclear power plant, the entire complement of nuclear plant operators be trained to perform their tasks and have in hand the necessary NRC licenses.

Consequently, utilities must ensure that there is an adequate number of individuals being trained to fill these positions.

Prior to the early 1970's, nuclear-fueled power plants looked to their experienced fossil operators and to former Navy reactor operators and technicians as the source of their nuclear workforce. In recent years, however, the fossil operators are less experienced and there is much more competition in the industry for ex-Navy operators. Therefore, utilities have established company- or contractor-operated training centers, providing the curricula and nuclear power plant experience that correlates with on-the-job training to prepare individuals to become nuclear plant operators. These training centers have produced the desired results, though too often at excessive costs to the utilities - costs subsequently borne by the public.

At least a portion of this training - technical preparation in nuclear and power plant fundamentals - can be provided by postsecondary, two-year vocational-technical schools.

The technical occupations described below carry an array of job titles. For simplicity, however, each is referred to by its most formal title.

Radiation Protection Technician: Conducts activities designed to protect workers, the general public, and the environment from exposure to ionizing radiation. Many of the activities are highly technical in nature, and include, 1) measuring of radiation and radioactivity levels in work areas and in the environment, 2) collecting and analyzing samples of air, water and other materials for radioactivity, 3) ensuring that regulatory requirements are adequately met. Thus, an individual involved in radiation-protection activities must have knowledge of radiation monitoring methods, instruments and calibration, as well as regulations and standards. In addition, those involved in radiation-protection activities must be able to work effectively with people with different goals and technical backgrounds.

Quality-Assurance/Quality-Control Technician: Tests, inspects and audits materials, equipment and processes to ensure that all are maintained within specified qualitative and quantitative limits.

The AQ/QC technician may conduct nondestructive testing of materials or use other methods for inspecting materials and workmanship in compliance with regulations and specifications. Duties may include electrical, civil, mechanical and welding inspection of equipment, materials, processes and structures during construction, operation and maintenance of a power plant.

Nuclear Instrumentation and Control (I&C) Technician: Electronics technicians trained in digital and analog circuitry and systems, as well as in nuclear radiation, its detection and measurement, process control instrumentation, electro-pneumatic, electro-mechanical and electro-hydraulic components and systems, are needed by every nuclear power plant.

Chemical Technician: The effluents and atmospheres within a nuclear facility require unique monitoring and maintenance processes. A chemistry technician employed in a nuclear facility requires special training to perform these unique tasks.

Power Plant Maintenance

Mechanics: As a part of a nuclear-fueled power plant's maintenance staff, such specialists as mechanics (and millwrights), machinists and welders must receive nuclear-specific training. Not only are they required to maintain and repair equipment unique to a nuclear plant, but also they must be intimately aware of the precision tolerances, procedural requirements and environmental conditions associated with the operation of a nuclear power plant.

Electricians: Unique technical problems, as well as extreme environmental (heat stress and radiation) conditions in nuclear-fueled power plants require general nuclear pre-employment training and orientation.

WORKFORCE NEEDS

At the end of 1978, around the world there were approximately 230 on-line nuclear-fueled electric power generating plants. The U.S., which leads the world in energy generating capacity and consumption, accounted for 72 of these plants. Additionally, 9 more plants are scheduled to become operational in the U.S. during 1979, and nearly 100 plants are in some state of construction or planning, all of which indicates some 185 nuclear-fueled plants in the U.S. alone by 1990.

Projections of Jobs

By assuming that each nuclear power plant requires an operations-and-maintenance workforce of 92 people (a taskforce estimate) at any given time in the categories mentioned previously, and that attrition will occur at a rate of 8 percent per year, a total workforce need over the next 15 years can be projected.

OPERATIONS-AND-MAINTENANCE WORKFORCE PROJECTIONS: U.S. NUCLEAR POWER PLANTS

	Col. #1	Col. #2	Col. #3	Col. #4	Col. #5
YR	# of Plants	Estimated # of subpro-fessionals (Col. #1 x 92)	Attrition (8%/yr) of workforce (Col. #2 x .08)	# of open positions (Annual Increase in Col. #2 + Col. #3)	# of new hires (Col. #4 x 1.25)*
78	70**	6440	515	1343	1679
79	79	7268	581	1685	2106
80	91	8372	670	2510	3138
81	111	10212	817	2381	2976
82	128	11776	942	1218	1522
83	131	12052	964	1332	1665
84	135	12420	994	1362	1702
85	139	12788	1023	1667	2084
86	146	13432	1075	1719	2149
87	153	14076	1126	2046	2558
88	163	14996	1200	2304	2880
89	175	16100	1288	2208	2760
90	185	17020	1362	2282	2852
91	195	17940	1435	2409	3036
92	205	18860	1509	2304	2880
93	213	19596	1568		
				15-Year Total	35098

Continuing requirements also can be projected for the major categories defined previously for nuclear-fueled power plants; for example:

* Workforce attrition plus 25% training attrition
**As of August 1, 1978.

MAJOR OPERATIONAL GROUPS	% OF TOTAL	NO. OF NEW HIRES NEEDED IN A SPECIFIED YEAR		
		1979	1984	1989
Plant (Reactor Operators	32.6	686	556	900
Radiation Protection	8.6	183	148	240
Maintenance (Mechanics - Electricians)	39.1	824	666	1079
Nuclear Instrumentation & Control	15.3	320	259	420
Quality Assurance/Quality Control	4.4	93	75	121
(COLUMN #5) TOTALS	100 %	2106	1702	2760

Manpower levels that may be required for the following industries, such as nuclear materials processing technicians, are not included in any of the fields above. In addition, government-owned, contractor-operated (GOCO) plants with nuclear materials processing facilities that have a continuing need for health-physics, cnemical and waste-handling technicians have been omitted for lack of data.

Employer identities

Who will employ this workforce?

Electric Utilities.

Fuel Processors:

Miners.

Process/Packagers.

Disposers.

Enrichment Installations.

Nuclear Research Organizations.

Nuclear Equipment Manufacturers.

Nuclear Facility Construction Organizations.

Training Organizations, Schools and Allied Service Organizations.

Military.

Department of Energy.

Other Federal, State and Local Government Agencies.

Shipbuilders.

Procedures for identifying employers in local areas are discussed later in this report, and a sample survey instrument appears in Appendix C.

EXISTING TRAINING PROGRAMS

Training of nuclear technicians occurs in schools and on the job in employer-sponsored programs.

Institutional Programs

Some twenty-one postsecondary schools in the United States have nuclear training programs for technicians. A listing of these schools and descriptive information concerning their programs appears in Appendix A. Cumulatively, graduates of these programs impact little if any the energy workforce requirements described in this report.

Employer Programs

Historically, the majority of nuclear operations and maintenance personnel appears to have received training from their employers after they were selected or hired to the nuclear power program. In the early years

of nuclear power, stet-training programs were not available. Thus the larger nuclear employers found it necessary to establish internal training capabilities. These programs have been augmented by 1) vendors' specialized training, and 2) private (consultant) training organizations, which smaller nuclear companies have used almost exclusively. Such training has been provided in both the basics and the specifics of a given plant. (See Appendix D.)

In addition, some training, usually in the radiation protection area, has been offered by governmental agencies. A few postsecondary schools also have developed ad hoc courses or programs for the developing nuclear industry.

Company programs, including those provided by vendors, most effectively focus upon areas of company-specific need; e.g., operating characteristics and license conditions peculiar to a specified reactor.

School programs should provide a more general technical background while developing a trained nuclear workforce especially appropriate to those categories defined earlier.

A USOE document, Nuclear Reactor (Plant) Operator Trainee, A Suggested Program Planning Guide, details the requirements and each step of planning and implementing a program for nuclear plant operator trainees, both in technical school settings and within industry. Similar documents will be available by late 1979 for these additional programs:

Nuclear Instrumentation & Controls Technician.

Nuclear Quality-Assurance/Quality-Control Technician.

Nuclear Materials Processing Technician.

Radiation Protection Technician.

School Program Considerations

Before committing to a nuclear program, school administrators and curriculum planners should give in-depth consideration to five major factors:

- Needs. Will a sufficient number of program graduates be needed in the future by employers within the school's service region? Note: National needs may be as significant as local needs in placing graduates.
- Relevance. School programs must be closely coordinated with industry to ensure that school programs incorporate subjects that can best be provided at the pre-employment level, or in off-the-job environments. A co-operative (co-op) program should be considered carefully and instigated if applicable. Continuous rapport with industry is an essential ingredient of a successful nuclear program. Schools must be willing to work within the needs of industry, and industry must be responsive to the thrusts of school programs.

- Location. The most effective programs take advantage of nearby (within 150 mile) university or research reactors for specialized training.
- Costs. A minimal nuclear program should occupy about 2,000 square feet of dedicated "hands-on" laboratory-instructional space. It may require ≈ $75,000 of unique capital equipment within the first two years of operation, a significant portion of which may be donated by industry or the U.S. Government. At least two faculty members will be needed: A program head at ≈ $25,000/year, and an instructor at ≈ $16,000-$18,000/year. Also, approximately $15,000 should be set aside for library and expendable materials. (See Appendix E, Cost Calculations.)
- Visibility. Public education to counteract adverse publicity should be promulgated along with directed efforts to recruit students for a nuclear program.

Employer Program Considerations

Before installing any specific nuclear training program, an employer usually reviews the following items:

- What are the options to an inhouse program?
  - Consultant's programs.
  - Vendor's programs.
  - School programs.
- What are the selection criteria?
  - Required competency level of trained employees.
  - Willingness of school or contractor to tailor program(s) to employer needs.

- Selection process for candidate students.
- Economics, which includes dependability of employee sources and availablility of training.

INSTRUCTIONAL MATERIALS

The basis of a sound instructional program is well prepared materials. If scrupulously reviewed by educators and employers, revised and tested, such materials best serve the instructional program, the students and the ultimate employers. The best materials also meet stringent content requirements for flexibility, relevance, currency and validity.

The U.S. Office of Education, Bureau of Adult and Occupational Education, is funding the development of 35 courses (236 modules) of instructional material designed especially for two-year, postsecondary institutions to prepare nuclear technicians and plant operator trainees. A complete listing of these materials is shown below:

Radiation Physics	Radiological Emergencies
Radiation Protection I	Radiation Shielding
Principles of Process Instrumentation	Radiation Monitoring Techniques
Heat Transfer and Fluid Flow	Radioactive Materials Disposal and Management
Introduction to Nuclear Systems	Advanced Radionuclide Analysis
Instrumentation and Control of Reactors and Plant Systems	Nuclear Chemical Processes
Reactor Operations	Nulear Systems and Safety
Reactor Safety	Radioactive Material Handling Techniques
Reactor Auxiliary Systems	Nondestructive Examination (NDE) Techniques I
Power Plant Systems	Metrology
Radiation Detection and Measurement	Welding Inspection
Reactor Physics	Civil/Structural Inspection
Power Plant Chemistry	Mechanical Inspection
Introduction to Quality Assurance/ Qualtiy Control	Qualtiy Assurance Practices
Metallurgy and Metal Properties	Nondestructive Examination (NDE) Techniques II
Mechanical Component Characteristics and Specifications	Quality Assurance and Reliability
Radiation Protection II	Advance Nuclear Instrumentation
Radiological Emergencies	Electrical Systems & Components

Over half of these course materials are completed and available from:

Technical Education Research Center - Southwest

4201 Lake Shore Drive
Waco, Texas 76710
(817) 776-8756

The remainder of these materials are under development and will be available by the end of 1979.

Several practical texts in nuclear fundamentals have been developed by federal and military agencies. Among these are the following:

- o Basic Physics for Nuclear Power Plant Operators

  U.S. Army Corps of Engineers
  Fort Belvoir, Virginia

- o Fundamentals of Nuclear Reactor Engineering

  U.S. Army Corps of Engineers

- o Radiation Protection

  U.S. Army Corps of Engineers

- o Radiation Health Handbook

  National Technical Information Service
  U.S. Department of Commerce, Springfield, Virginia 22161

The Department of Energy published numerous booklets on selected technical topics relevant to nuclear technician training. These documents are available, free of charge, from:

U.S. Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, Tennessee 37830

Some employers in the nuclear power industry have developed their own instructional materials in nuclear power operations and maintenance.

These employers include:

Commonwealth Edison Co. (Mr. John Gammuto)
72 West Adams Street
Chicago, Illinois 60690

Duke Power Co. (Mr. Richard Marzec)
P.O. Box 666
Cornelius, North Carolina 28231

Pacific Gas and Electric
77 Beale Street
San Francisco, California 94106

Employers also purchase training services and instructional materials from various sources, including the following:

Vendors -

General Electric Co.
BWR Training Center
Route 1, Box 220
Morris, Illinois 60450

Babcock & Wilcox, Power Generation Division
Manpower Training & Development
P. O. Box 1260
Lynchburg, Virginia

Westinghouse Electric Corporation
Nuclear Training Division
Pittsburgh, Pennsylvania

Consultants -

General Physics Corporation
1000 Century Plaza
Columbia, Maryland 21044

Nuclear Utilities Services, Inc.
4 Research Place
Rockville, Maryland 20850

APPENDIX A

TWO-YEAR, POSTSECONDARY SCHOOLS WITH NUCLEAR PROGRAMS

TWO-YEAR, POSTSECONDARY

SCHOOLS WITH NUCLEAR PROGRAMS

	No. of Students Enrolled 1978-79	Instructional Materials Used	Co-op with Industry
Aiken Technical Education Center (Nuclear Engineering Technology) Dr. Tek Chand, Chairman P. O. Drawer 696 Aiken, SC 29801	38	TERC	No
Central Florida Community College (Raidological Health Technology) Frank Holland, Instructor P. O. Box 1388 Ocala, FL 32670 904/237-2111 X277	126	Various	Yes
Central Virginia Community College (Nuclear Technology) Edgar Dewell, Assoc Professor P. O. Box 4098 Lynchburg, VA 24502 804/239-0321	4	In-house	No
Chabot College (Nuclear Technology/Radiation Technology in conjunction with Lawrence Livermore) 25555 Hesperian Boulevard Hayward, CA 94545 415/786-6600	30	Various	Yes
Chattanooga State Tech. Community Col. Division of Life & Health Sciences Dr. D. R. Stone - Head (Nuclear Technology) 4501 Amnicola Highway Chattanooga, TN 37406 615/622-6262	56	Various	No
Columbia Basin College (Nuclear Technology) Larry DeWitt, Instructor 2600 North 20th Pasco, WA 99301 509/547-0511	30	DeWitt TERC Gen. Phys.	No
Community College of Beaver County (Nuclear QA Technology) Lawrence Cook, Instructor Monaca, PA 15061 412/775-8561	28	Various	Yes

Eastern Idaho Vocational Technical School (Nuclear Technology) Elton King 2299 East 17th Street Idaho Falls, ID 83401 208/524-3000	54	Various	Yes
Florence-Darlington Tech. College (Nuclear Engineering Technology) Dr. Wayne D. Leonard, Dept. Head P. O. Drawer 8000 Florence, SC 29501 803/662-8151	20	TERC	Yes
Hartford State Technical College (Nuclear Technology) Fred Baker, Dept. Head 401 Flatbush Avenue Hartford, CT 06106	4	--	No
Lakeshore Technical Institute (Health Occupations) George Gruber, Supervisor 1290 North Avenue Cleveland, WI 53015 414/693-8211	0 (Begins Fall, 1979)	TERC	--
Los Angeles City College (Nuclear Technology) Jack Smith 855 North Vermont Avenue Los Angeles, CA 90029 213/663-9141 X335	17	Various	Yes
Memphis State University (Center for Nuclear Studies) Dr. D. Wayne Jones, Director Memphis, TN 38152 901/454-2861	42	In-house	Yes
Mississippi Gulf Coast Junior Col. Jackson County Campus (Nuclear Radiation Control Technology) Dr. Larry McKay, Director Gautier, MS 39553 601/497-4313 X218 and 233	17	TERC	No
Oklahoma State University-Main Campus (Nuclear Technology) 900 North Portland Stillwater, OK 74074	40	Various	No
Pennsylvania State University Altoona Campus (Nuclear Engineering Technology) Dr. Lawrence Pilione Altoona, PA 16601 814/946-4321	14	Various	No

Pennsylvania State University Hazelton Campus (Nuclear Engineering Technology) Anthony Galanti, Chairman Hazelton, PA 18201 717/454-8731	12	Various	No
Terra Technical Institute (Nuclear Power Technology) 1220 Cedar Street Fremont, OH 43420	45	TERC and others	No
Texas State Technical Institute James Connally Campus (Nuclear Technology) Waco, TX 76705	22	TERC	No
Tri-County Technical College (Nuclear Technology) P. O. Box 87 Pendleton, SC 29670 803/646-3227	17	TERC and others	No
Tuskegee Institute (Radiation Safety Comm.) Mr. Philip A. Loretan Radiation Safety Officer Tuskegee Institute, AL 36088 205/727-8011	10	Various	Yes

APPENDIX B

JOB DESCRIPTIONS

NUCLEAR PLANT OPERATOR

Job Description - Control reactivity changes in a safe manner utilizing normal and emergency operating procedures. Perform other nuclear reactor and non-reactor duties as assigned by supervisory personnel. Function within the entire facility.

Other Job Titles

Nuclear Power Plant Operator	Senior Control Operator
Watch Engineer	Shift Foreman
Auxiliary Equipment Operator	Shift Engineer
Unit Operator	Licensed Operator
Utility Operator	Licensed Senior Operator
Control Operator	Fuel Handling Technician

Task List and Required Knowledge by Law

Fundamentals of reactor theory, including
- Fission process.
- Energy release.
- Neutron multiplication.
- Source effects.
- Control-rod effects.
- Criticality indications.

Understand design features of core, including:
- Core structure.
- Fuel elements.
- Control rods.
- Core instrumentation.
- Coolant flow.

Mechanical design features of the reactor primary system, steam system, condensate and feedwater control systems and auxiliary systems.

General operating characteristics, including:
- Causes and effects of temperatures.
- Pressure and reactivity changes.
- Effects of load changes.
- Operating limitations and reasons for them.

Design, components and functions of reactivity control mechanisms and instruments.

Design, components and function of safety systems, including:
- Instrumentation.
- Signals.
- Interlocks.
- Automatic and manual features.

Components, capacities and functions of reserve and emergency systems.

Shielding, isolation and containment design features, including access limitations.

Standard and emergency operating procedures for the facility (plant).

Purposes and operations of radiation monitoring systems, including alarm and survey equipment.

Radiological safety principles and procedures.

Prestartup procedures for facility, including associated plant equipment that can affect reactivity.

Manipulation of console controls to bring the facility from shut down to designated power levels and return to shut down.

Source and significance of annunciator signals, and conditions indicating signals and responsive remedial actions.

Instrumentation systems, and the source and significance or reactor instrument readings.

Behavior characteristics of facility.

Control manipulation required to obtain desired operating results during normal, abnormal and emergency situations.

Operation of facility heat removal system, including:
- Primary coolant systems.
- Emergency coolant systems.
- Decay heat removal systems.
- Steam systems.
- Condensate and feedwater systems.
- Relation of the proper operation of these systems to operation facility.

Significance of radiation hazards, including:
- Permissible levels.
- Levels in excess of those authorized.
- Procedures to reduce excessive levels and guard against personnel exposure.

Use and function of facility's radiation monitoring systems, including:
- Fixed radiation monitoring systems.
- Alarms.
- Portable survey instruments.
- Personnel monitoring equipment.

Emergency plan for facility including:
- Responsibility to decide whether plan should be executed, and duties assigned under the plan.

Necessity for a careful approach to responsibilities associated with safe operation of facility.

Radiation waste operation.

Regulations -- 10CFR 19, 20, 55, 50 and 100.

Technical Specifications.

Licensing process.

Start up and control cooperation of nuclear reactor in which heat is used to produce steam for the purpose of generating electricity, and/or process steam.

Monitor instruments and record data in control room to control chain reaction, steam production and auxiliary systems.

Conditions and limitations in the facility licenses, or authorization.

Design and operating limitations in facility operating procedures, administrative procedures and technical specifications.

Procedures and limitations involved in initial core loading, alterations in core configurations control-rod programming, determination of various internal and external effects on core reactivity.

Fuel-handling facilities, procedures and refueling techniques.

Procedures and equipment available for handling and disposing of radioactive materials and effluents.

References

Code of Federal Regulations, Chapter 1, Title 10, Parts 55, 50, 20, 19 and 100.

NUREG 1094, NRC operator licensing guide.

Regulator guide 1.8, "Selection and Training of Personnel."

ANSI N3.1, "Selection and Training of Nuclear Power Plant Personnel."

WASH 1130, "Utility Staffing and Training for Nuclear Training."

NUCLEAR PLANT OPERATOR TRAINEE

Job Description - Entry level to utilities, further trainin either on-the-job or at a simulator. Additional training and job experience should lead evenutally to a Nuclear Plant Operator's License.

Task List and Required Knowledge

Fundamentals of reactor theory, as applicable to the fa lity, including:

- Fission process.
- Neutron multiplication.
- Source effects.
- Control-rod effects.
- Criticality indications.

Understand design features of core, including:

- Core structure.
- Fuel elements.
- Control rods.
- Core instrumentation.
- Coolant flow.

Mechanical design features of reacotr primary system, system systems, condensate and feedwater systems, and auxiliary systems.

General operating characteristics, including:

- Cause and effects of temperature.
- Pressure and reactivity changes.
- Effects of load changes.
- Operating limitations, and reasons for them.

Design, components and functions of reactivity control mechanisms and instruments.

Design, components and functions of safety systems, including:

- Instrumentation.
- Signals.
- Interlocks.
- Automatic and manual features.

Components, capacities and functions of reserve and emergency systems.

Shielding, isolation and containment design features, including access limitations.

Radiation waste operation.

Regulations - 10 CFR 19, 20, 55, 50 and 100.

Technical Specifications.

Licensing process.

Significance of radiation hazards, including:
- Permissible levels.
- Levels in excess of those authorized.
- Procedures to reduce excessive levels and guard against personnel exposure.

Fundamentals of power plants, including:
- Pumps.
- Valves and piping.
- Heat exchangers.
- Turbines and generators.
- Transmission and distribution equipment.
- Waste treatment processes and equipment.
- Quality-control procedures.

RADIATION PROTECTION TECHNICIAN

Job Description - Radiation protection activities are designed to protect workers, the general public, and the environment from untoward exposure to ionizing radiation. Many of the activites are highly technical in nature, and include measurement of radiation and radioactivity levels in work areas and the environment, collecting and analyzing samples of air, water, and other materials for radioactivity, and ensuring that regulatory requirements are adequately met. Thus, an individual involved in radiation protection activites must have knowledge of radiation monitoring methods, instruments and calibration, and regulations and standards. In addition, those involved in radiation protection activities must be able to work effectively with people with different goals and technical backgrounds.

Required Knowledge

Elementary nuclear and atomic physics.

General chemistry.

Biological effects of radiation.

Radiation regulations and standards.

Radiation measurement techniques.

Elementary algebra.

Task List

Monitors personnel, the plant, and the environment for radioactive contamination.

Conduct radiation surveys of the working environment.

Collect and analyze for radioactivity samples of gaseous and liquid effluents and environmental media.

Maintains and calibrates radiation monitoring and counting instruments.

Monitors radiation exposure, both internal and external, to plant workers.

Verifies implementation of radiation protection regulations, standards and procedures.

Documents findings and assists with the evaluation of data.

Assists in the preparation of reports.

QUALITY-ASSURANCE/QUALITY-CONTROL TECHNICIAN

Job Description - Performs tasks, inspections, checks and audits to ensure that a facility, component or activity has been fabricated, installed, operated or maintained in accordance with specifications and/or regulations. Assists in preparation of documents and records of compliance established by standards, specifications and regulations.

Other Job Titles

Civil and/or Structural Inspector (or Technician)
Mechanical Quality-Control Inspector (or Technician)
Electrical Quality-Control Inspector (or Technician)
NDE Inspector (or Technician)
Welding Quality-Control Inspector (or Technician)

Task List and Required Knowledge

Keep thorough and accurate records.

Read and interpret drawings, specifications, codes and standards.

Identify components of and inspect to determine the quality (by verifying that records are certified) of pumps, valves, seals and piping.

Perform instrument readings and calibration procedures.

Determine and/or verify proper storage and handling of components such as in heated areas, inert-gas atmospheres, air-conditioned areas, and humidity-controlled areas.

Write complete reports, such as results of equipment inspections, radiographs, Nondestructive Examinations (NDE), surveys, construction inspections, and acceptance tests.

Understand and apply codes (such as the ASME Boiler and Pressure Vessel Code) and regulations, and regulatory guides.

Inspect the quality of various types of weld joints for a variety of material types and weld configurations.

Verify metallurgical examinations, such as hardness, tensile strength and notch ductility.

Understand basic metallurgical processes, such as heat treating and welding.

Use strain gages, vibration tester and similar equipment.

Make accurate dimensional measurements with its use of micrometers, go/no-go gages, gage blocks and similar equipment.

Operate measuring instruments and test equipment.

Assist in preparing procedures, instructions and records that serve to instruct and guide the accomplishment of QA/QC tasks.

Understand criteria for passing or failing QC tests.

Verify control of conditions during tests, including ambient or environmental conditions.

Perform and verify NDE procedures (according to qualification and training of the inspector.)

Follow test procedures; obtain and/or verify amount and kind of data needed.

Measure force, momentum, surface roughness, mass, temperature, pressure, hardness, etc. with the use of appropriate equipment.

Assist in evaluation of customer requirements.

Review documentation for standards conformance.

Validate proof and qualification tests.

Provide information on previous quality problems.

Evaluate the quality of work performed by potential vendors.

Review purchase orders and subcontracts for quality requirements.

Ensure that purchased materials conform to requirements.

Identify materials or components which do not conform to specified requirements.

Ensure that operating equipment, testing and test equipment, and processes meet the required specifications.

Ensure that measuring and test equipment is calibrated and maintained.

Conduct follow-up examinations to ensure that corrective action is accomplished in a timely manner.

Verify compliance of the handling, preservation and packaging of material and equipment, from receipt through shipment and/or installation.

Ensure that spares and technical supplies conform to quality requirements.

Ensure that repairs and modifications are performed in accordance with approve standards and/or prcedures.

NUCLEAR INSTRUMENTATION AND CONTROL TECHNICIAN

Job Description - Selects and utilizes appropriate measuring instruments in performing preventive and corrective maintenance on neutron flux level instruments, area and process radiation monitoring systems, personnel protection instruments, non-nuclear measurement, control and indication devices. This is primarily an Electronic Instrumentation Technician with a speciality in Nuclear fundamentals and detectors, and process control systems.

Other Job Titles

Control System Technician.
Instrumentation and Control Technician.
Instrumentation and Control Design Assistant.
Process Instrument Technician.
Journeyman Instrument Mechanic.

Task List and Required Knowledge

Perform routine inspections of equipment.

Perform prestartup checks and calibrations.

Calibrate equipment after repair.

Troubleshoot malfunctioning equipment.

Perform routine maintenance on various types of equipment (nuclear and process instrumentation) that utilizes mechanical, electronic, pneumatic and hydraulic.

Calibrate new equipment.

Assist in transducer selection.

Assist in determining signal conditioning requirements.

Assist in signal processing equipment selection.

Assist in output devise selection.

Perform error analysis measurements.

Construct calibration charts.

Assist in equipment performance monitoring.

Perform preventive maintenance.

Maintain control systems.

Assist in developing procedures, records and schedules for systems maintenance, repairs and calibrations on system devices.

Performs or assists in computer system maintenance.

Provide basic maintenance upkeep in computer instrumentation.

Maintain a system of check procedures and schedule routine inspections of computer systems.

Repair and calibrate various system devices.

NUCLEAR CHEMICAL TECHNICIAN

Job Description - Performs laboratory analyses of a variety of process and effluent samples by appropriate chemical, physical, instrumental, and radiochemical techniques. An important aspect of this effort is chemcial control of reactor coolants, as well as analyses of effluents to ascertain whether or not their chemical contents fall within acceptable discharge limits.

Required Knowledge

Basic physics.
General chemistry.
Qualitative adn quantitative analyses.
Elementary algebraic operations.
Elementary organic chemistry.
Radiochemical techniques.
Instrumental analysis techniques.
Power plant systems.

Task List

Samples and conducts chemical analyses of reactor effluents.

Samples and performs chemcial analyses of reactor coolants and other process fluids.

Prepares standard solutions.

Maintains calibration standards for analytical instrumentation.

Assists in the preparation of reports and evaluations of reactor conditions based on the data generated.

Performs radiochemical analysis of reactor fluids.

Electrician

Job Description - Trouble shoots and maintains station electrical equipment and devices, such as:

Main generators.
Motors.
Transformers.
M-g sets.
Batteries.
Switch gear.
Switch-yard equipment.
Electrical circuits (up to 416)VAC).

Usually not involved with control or relay work. Work must meet precision tolerances.

Mechanic

Job Description - Trouble shoots and maintains station mechanical equipment and devices, such as:

Turbines.
Condensers.
Pumps and Compressors.
Piping.
Heat exchangers.

May be required to weld. May be required to operate lathes, milling machines and related equipment. Work must meet precision tolerances.

APPENDIX C

LOCAL NEEDS SURVEY

(SAMPLE INSTRUMENT)

SUGGESTED WORKFORCE NEEDS SURVEY INSTRUMENT FOR NUCLEAR TECHNICIAN AND REACTOR OPERATOR TRAINEES

Dear Sir:

I am writing to ask for your help. Our school is considering the establishment of a 2-year technical program in the new field of nuclear power plant operation. Prior to establishing such a program, I have been asked to conduct a survey of the present and future needs in this locale for technicians with this special training. I have enclosed the survey, which should take just a few minutes to complete. When you are done, simply place this survey in the enclosed stamped addressed envelope and return. If you wish a copy of the results of the survey, please so indicate at the end of the questionnaire.

If, for some reason, this questionnaire does not apply to your specific area of responsibility at your organization, please pass it on to someone to whom it may be more appropriate.

I sincerely appreciate your efforts in behalf of this new occupational training program in the state.

Sincerely,

TYPICAL WORKFORCE NEEDS SURVEY INSTRUMENT FOR NUCLEAR TECHNICIAN AND REACTOR OPERATOR TRAINEES

Name of company, institution, or government division:

_____

_____

Definitions: Nuclear Reactor (Power Plant) Operator - A person responsible for proper daily routine and emergence operation of nuclear reactor or nuclear power plant.
Trainee - As a trainee the person is gaining the information and experience to properly operate the reactor (or plant) and preparing to be examined for licensing by the Nuclear Regulatory Commission.

	Yes	No	
1.	_____	_____	Does your company currently employ people who are licensed or are under training for licensing as Nuclear Reactor Operators?

2. _____ _____ Do you have current vacancies for Nuclear Reactor Operators and trainees?

3. Please indicate the typical beginning salary a Nuclear Reactor Operator Trainee might expect to receive in your company.

a.	$700-800/mo. _____	d.	$1200-1400/mo _____
b.	$801-1000/mo. _____	e.	$1401-1600/mo. _____
c.	$1001-1200/mo _____	f.	Greater than $1600/mo _____

4. In your opinion, your need for Nuclear Reactor Operator Trainees during the next ten years will:

_____ decrease	_____ Increase by 26-50%
_____ remain the same	_____ Increase by 51-75%
_____ Increase by 0-25%	_____ Increase 76-100% or more

5. Can you give an estimate of the total number of Nuclear Reactor Operator Trainees you will need in the next five year period?

1978	_____	1981	_____
1979	_____	1982	_____
1980	_____		

6. As you employ Nuclear Reactor Operator Trainees in the future would you:

_____ prefer to train these individuals yourself?

_____ prefer to hire individuals trained in nuclear plant fundamentals in a recognized and approved institution?

7. Please circle those items in which you think the Nuclear Reactor Operator Trainee should receive specific training:

I. Fundamentals of reactor theory.
   - A. Fission process.
   - B. Energy release.
   - C. Neutron multiplication.
   - D. Source effects.
   - E. Control rod effects.
   - F. Criticality indications.

II. Design features of core.

III. Mechanical design features of the reactor system.

IV. General operating characteristics.
   - A. Causes and effects of temperature.
   - B. Pressure and reactivity changes.
   - C. Effects of load changes.
   - D. Operating limitations and reasons for them.

V. Design, components and functions of reactivity control mechanisms and instrumentation.

VI. Design, components and functions of safety systems.
   - A. Instrumentation.
   - B. Signals.
   - C. Interlocks.
   - D. Automatic and manual features.

VII. Components, capacity and function of reserve and emergency systems.

VIII. Shielding, isolation and containment procedures for the facility/plant (specific).

IX. Balance of plant - turbines, condensers, pumps, valves, piping, heat exchangers, generators, and auxiliary equipment.

X. Other - Please list.

8. Due to specific duties, titles for a Nuclear Reactor Operator may vary; which of the following titles are used by your company to describe these individuals?

____ Test Reactor Operator.
____ Research Reactor Operator.
____ Nuclear Power Plant Operator.
____ Watch Engineer.
____ Auxiliary Equipment Operator.
____ Unit Operator.
____ Reactor Irradiation Servicing Technician.
____ Control Operator.
____ Senior Control Operator.
____ Shift Foreman.
____ Shift Engineer.
____ Licensed Reactor Operator.
____ Licensed Senior Reactor Operator.
____ Simulator Instructor.
____ Fuel Handling Technician.

9. Please indicate the type and manufacturer of reactor your company operates:

____ Boiling Water Reactor
____ Pressurized Water Reactor.
____ Research Reactor.
____ Other _____.

10. Would you classify your company's principal endeavor as:

____ Electrical power production.
____ Research and development.
____ Nuclear materials processing and disposal.
____ Equipment manufacturer.
____ University or private training consultant.
____ Other (specify) _____.

11. Comments: Please include any additional information which you feel would help us identify the need in numbers and competencies for Nuclear Reactor Operators.

_____

_____

_____

_____

12. _____ Yes _____ No Would you like to receive a copy of the report summarizing the results of this survey?

Please mail to: _____

_____

_____

_____

Your kind assistance in completing this survey questionnaire is appreciated.

APPENDIX D

INDUSTRIAL AND GOVERNMENTAL TRAINING PROGRAMS

INDUSTRY TRAINING PROGRAMS

Planning a training program within an industry differs from institutional planning - employer needs dictate program content. The following examples of industrial preparation programs for nuclear operator trainees show various approaches, all of which have proved to be effective.

Duke Power Company Operator Training Program

The Duke Power program content is based on the needs of a new employee with no power plant experience or training. The following chart depicts advanced placement of trainees with particular backgrounds. Graduates of two-year nuclear technology programs are placed on the same level as ex-military nuclear personnel.

Duke's basic program spans 49 weeks. The advanced portion (31+ weeks) involves on-the-job and license preparatory training, with little time spent in the classroom.

DUKE POWER COMPANY
NUCLEAR OPERATOR CURRICULUM

	Weeks
General Station Training:	
Orientation	1
Basic Training:	
Systems & Components (General)	2
Systems & Components (Specific)	24
Nuclear Preparatory	12
Advanced Training:	
Nuclear Fundamentals	11
Systems & Procedures (Specific On-the-Job Training)	46
License Preparatory-Operator	24
License Preparatory - Senior Operator	

DUKE POWER COMPANY OPERATOR TRAINING PROGRAM
FOR VARIOUS BACKGROUNDS

	BASIC				ADVANCED			
Background	OR	SCG	SCS	NP	NF	SPS	SIM	LP
Fossil Plant	X		P	X	X	X	X	X
Technical School Graduate/ Military Nuclear	X		P		P	X	X	X
Power Plant Licensed Operator	X					X	X	X
Engineering Graduate	X	X	P	Excpt NE X	Excpt NE X	X	X	X
Non-trained/ Non-experienced	X	X	X	X	X	X	X	X

LEGEND:
- OR — Orientation
- SCG — Systems and Components (General)
- SCS — Systems and Components (Specific)
- NP — Nuclear Preparatory
- NF — Nuclear Fundamentals
- SPS — Systems and Procedures (Specific)
- SIM — Simulator
- LP — License Preparatory
- X — All Topics
- P — Partial or Short Course
- Excpt NE — Except Nuclear Engr.

Parallel topics of study for Duke trainees in the basic program and the nuclear materials described in this Guide (Appendix B) include:

Systems and Components (General):
Courses 3, 9, 10, 13.

Systems and Components (Specific):
Courses 4, 5, 6, 12, 13, 16.

Nuclear Preparatory:
Courses 1, 2, 5, 6, 11, 12, 15.

Also, several modular courses encompass material covered in the advanced portion of Duke's program:

Nuclear Fundamentals:
Courses 3, 4, 8, 10.

License Preparatory:
Courses 7 and 14.

Babcock and Wilcox Operator Training Program

The complete B & W program consists of seven courses, designed as a package to fulfill NRC "cold" operator license requirements. Included in the typical nine-month instructional program are courses in basic nuclear theory, observation experience, systems description, simulator operation and pool reactor operation. An eleven-week on-the-job coordination period for trainees, supervised by B & W instructors, is optional.

The modular nuclear curriculum described in this Guide covers all areas of basic nuclear theory and system description, while lending itself to those institutional or industrial programs with a simulator access.

Materials provide a basis for curriculum planning; however, this Guide recognizes that much more goes into the creation of a successful training program. In the Planning & Program section, total program planning is discussed.

BABCOCK AND WILCOX
OPERATOR TRAINING PROGRAM

	Weeks
Basic Nuclear Theory: Mathematics, atomic physics, reactor physics, heat transfer, introductory nuclear instrumentation, shielding and health physics	13
Practical Observation Experience.	8
Nuclear Steam Supply System & Operations.	4
PWR Simulator Operation.	8
Reactor Operation (at least 10 startups).	2
On-the-Job Coordination.	44

TVA Operator Training Program

TENNESSEE VALLEY AUTHORITY (TVA)
NUCLEAR REACTOR OPERATOR TRAINING PROGRAM

Phase	I 5 Mo	II 5 Mo	III 6 Mo	Parallel TERC Course No.
Cleaning	15	10	10	8
Safety Practices				
Ind. Safety	10			
Rad. Safety	60	10	10	1,2,11
Operating Procedures	15	36	40	7,6
Reactors and Auxiliary Equipment	24	70	210	5,9,12
Plant Records	10	8	5	14
Feedwater System	33	85	80	4,13
Steam Turbines and Condensers	10	136	10	10
Fuel Handling	0	29	60	7
Radioactive Waste	0	24	50	13
Miscellaneous Plant	27	120	30	
Meters and Instruments	15	35	25	3,6
General Inspection	23	5	15	14
Miscellaneous	13	40	5	15
Controls - Interlocks	25			16
Transmission - Substation	50		20	10
Generators - Exciters	35		20	10
Auxiliary Electric Equipment	35		20	10
Technical Instruction	400	192	350	
Total Hours	300	300	960	
	Classroom/Plant Observation/ Simulation			

The basic TVA program (Phase I, II and III) spans 16 months, with each day divided into 3 1/2 hours of classroom instruction and 3 1/2 hours of inplant observation. The operator trainee is a TVA employee, but may be dismissed for failure to pass any one training phase examination.

SAMPLE COSTING CALCULATIONS

Sample Calculation No. 1.

Assumptions:
- 24 1st-yr students.
- 16 2nd-yr students.
- 14 grads annually after 2nd yr.
- 1 Dept. head @ $24,000 1st yr salary.
- 1 Instructor (beginning 2nd yr) @ $18,000 1st yr salary.
- 1/2 Secretary @ $8,000 1st yr salary.
- Benefits and overhead (B & O) equal to 50% of annual salaries.
- Facility modifications cost of $25,000.
- Initial capital equipment cost of $50,000 (for 1st-yr courses only).
- Additional capital equipment cost of $63,000 for 2nd-yr courses.
- Annual expendables cost of $10,000 for both 1st- and 2nd-yr courses.
- Miscellaneous annual costs of $4,000 (library, travel, seminars, etc.).

Calculation:

Initial expenditures	Facility	25,000.00		
	Equipment	50,000.00		
			$ 75,000.00	
1st-yr expenditures	Dept. head	24,000.00		
	Secretary	4,000.00		
	B & O	14,000.00		
	Expendables	5,000.00		
	Misc.	2,000.00		
			$ 49,000.00	
			124,000.00	
2nd-yr equipment expenditures			63,000.00	
2nd-yr expenditures	Dept. head	24,000.00		
	Secretary	4,000.00		
	Instructor	18,000.00		
	B & O	23,000.00		
	Expendables	10,000.00		
	Misc.	4,000.00		
			$ 83,000.00	
			270,000.00	

If equipment and facilities costs are amortized over a five-year period, the following approximations apply:

Exp. Item	1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
Personnel*	$ 28,000	$ 47,400	$ 49,770	$ 52,260	$ 54,870
Ben. & Ovhd.	14,000	23,700	24,885	26,130	27,435
Equipment	10,000	25,750	25,750	25,750	25,750
Facilities	5,000	5,000	5,000	5,000	5,000
Expendables	5,000	5,000	5,000	5,000	5,000
Misc.	2,000	4,000	4,000	4,000	4,000
Annual Totals	$ 64,000	$115,850	$119,405	$123,140	$127,055

*5% annual salary increase included.

Sample Calculation No. 2.

Assumptions:
- 12 1st-yr students.
- 8 2nd-yr students.
- 6 grads annually after 2nd yr.
- 1 Dept. head/instructor @ $20,000 1st-yr salary.
- 1/2 Secretary @ $6,000 1st-yr salary.
- B & O equal to 40% of annual salaries.
- Facility modification cost of $5,000.
- Initial capital equipment cost of $35,000 (for 1st-yr courses only).
- Additional capital equipment cost of $48,000 for 2nd-yr courses.
- Annual expendables cost of $5,000 for both 1st- and 2nd-yr courses.
- Miscellaneous annual costs of $2,500 (library, travel, seminars, etc.).

Calculation:

Initial expenditures	Facility	5,000.00	
	Equipment	35,000.00	
			$ 40,000.00
1st-yr expenditures	Dept. head	20,000.00	
	Secretary	4,000.00	
	B & O	9,600.00	
	Expendables	2,500.00	
	Misc.	250.00	
			$35,350.00
			77,350.00
2nd-yr equipment expeditures			48,000.00
2nd-yr expenditures	Dept. head	21,000.00	
	Secretary	4,200.00	
	B & O	10,080.00	
	Expendables	5,000.00	
	Misc.	2,500.00	
			$ 42,780.00
			$168,130.00

If equipment and facilities costs are amortized over a five-year period, the following approximations apply:

Exp. Item	1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
Personnel*	$ 24,000	$ 25,200	$ 26,800	$ 28,140	$ 29,550
Ben. & Ovhd.	9,600	10,080	10,720	11,260	11,820
Equipment	7,000	19,500	19,500	19,500	19,500
Facilities	1,000	1,000	1,000	1,000	1,000
Expendables	2,500	5,000	5,000	5,000	5,000
Misc.	1,250	2,500	2,500	2,500	2,500
Annual Totals	$ 45,350	$ 63,280	$ 65,520	$ 67,400	$ 69,370

*5% annual salary increase included.

Sample Calculation No. 3.

Assumptions:
- Facility diversion: $50,000.
- Equipment diversion: $50,000.
- On-staff instructor(s) - annual salary $28,000.
- 1/2 Secretary - annual salary $9,000.
- B & O 50% of annual salaries.
- Annual expendable cost of $1,000/ student.
- Miscellaneous cost of $250/student.
- 10 students/yr.

Calculation:

1st-yr expenditures	Facility	$ 50,000.00	
	Equipment	50,000.00	
	Instructor	28,000.00	
	Secretary	4,500.00	
	B & O	16,250.00	
	Expendables	10,000.00	
	Misc.	2,500.00	
			$161,250.00

Note: This calculation suggests costs for academic preparation only; it does not include observation, simulator training or coaching for NRC license examination.

Estimated Library Material Cost.

Library materials for this technology, predicated on 1977 costs, may be estimated as follows:

Initial costs -

	Maximum	Minimum
References	$ 2,000.00	$ 1,000.00
Journals	300.00	150.00
Periodicals	150.00	75.00
Miscellaneous	150.00	.00
	$ 2,600.00	$ 1,225.00

Annual costs -

References	300.00	150.00
Journals	300.00	150.00
Periodicals	150.00	75.00
Miscellaneous	150.00	.00
	$ 900.00	$ 375.00